Experimental procedure to determine the effectiveness of Phase Change Materials to cool a railgun armature

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Introduction

Railguns have been proposed by Nasa as a low cost propulsion system to assist in sending payloads into orbit. One of the unaddressed technical challenges associated with this launch technic is the heat generated in the armature of the railgun during the electric pulse. The heat generated by the intense current flux through the armature is likely to cause structural damage to the armature and the payload. This study proposes to use Phase Change Materials (PCMs) to cool the railgun armature. PCMs have the property of undergoing phase changes, solid to liquid in this case, when exposed to heat. During the phase change of a PCM, all the heat absorbed is used to continue the phase change instead of increasing the PCMs temperature. The physical properties of PCMs make them ideal for increasing the latent heat of railgun armatures. The first step in this study is to assess the effectiveness of different PCMs in absorbing excess heat from Ohmic heating through an experiment.

Methods

The goal of the experiment is to closely simulate the conditions in which an armature will be subject to when being fired out of a railgun. The experiment achieves this through the use of a 10000uF capacitor bank connected to three circuits:

- A charging circuit turning an AC source into DC current for the capacitor bank
- A safe discharge circuit to short the capacitor bank safely after use
- A sample testing circuit to simulate the ohmic heating generated in the armature

Since the ideal material for an armature is aluminum, this experiment uses aluminum foil to close the sample testing circuit. The reaction of the samples to electric pulses will be monitored as samples with and without PCM coatings are tested.

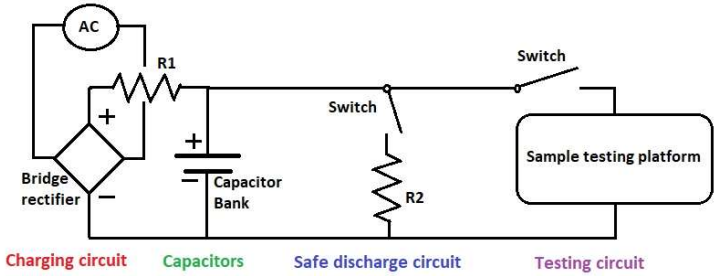

Figure 1 – Circuit diagram of the experiment

Results

All parts of the experiment, with the exception of the sample testing platform, have been built and assembled. The charging circuit, capacitor bank, and safe discharge circuit have undergone continuity testing.

Figure 2 – Pictures of the assembled experiment

Future work

The next steps in this research project are:

- cycle the circuit through phases of charges and safe discharges.
- Build and assemble the testing circuit
- Test samples with and without PCM coating and monitor the effects of PCMs on heat management

The results of the study will be presented at the next student symposium.

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